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ABSTRACT

The purpose of this paper was to explore the literature to see what differences, if any, exist between the sexes in mathematics achievement from pre-school through high school levels. Thirty-three studies were reported. Findings showed that there were no significant differences between boys' and girls' mathematics achievement in pre-school or early elementary years. In upper elementary and early high school years, significant differences were not always apparent; however, when significant differences did appear they were more apt to be in the boys' favor when the higher-level cognitive tasks were being measured and in the girls' favor when lower-level cognitive tasks were measured. No conclusions were reached concerning high school learners. Six questions were raised concerning the relationship between sex differences and mathematics achievement. (DT)

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MATHEMATICS LEARNING AND THE SEXES: A REVIEW

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Are there really sex differences in mathematics achievement? A Guide to Current Research: Elementary School Mathematics (Glennon and Callahan, 1968, p. 30) states that "The evidence would suggest to the teacher that boys will achieve higher than girls on tests dealing with mathematical reasoning while the girls will achieve higher than boys on tests of computational ability." An equally prestigious review of research (Suydam and Riedesel, 1969, p. 129) states that there are no significant differences between the sexes in arithmetic achievement before 7th grade but boys surpass girls after 7th grade. Aiken (1971, p. 203) states that "Sex differences in mathematical abilities are, of course, present at the kindergarten level and undoubtedly earlier." One could conclude from these reviews that a sex difference in learning mathematics does exist and that it is in favor of boys. However, Parsley et. al. (1963, 1964) in two of the few studies concerned basically with sex as an important variable, found few if any significant differences between boys' and girls' learning of mathematics.

Is boys' superiority in the learning of mathematics a myth or is it a reality? The purpose of this paper is to explore the literature in depth to see what differences if any do exist between the sexes in mathematics achievement. If sex differences do not exist, then educators should discard their belief about boys' superiority. However, if there are sex differences in learning mathematics, then the mathematics education profession has a direct responsibility to provide research data, curricular materials and teacher training that will enable boys and girls equally to fulfill their

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cognitive potential in mathematics.

The studies that have been included are those reported since 1960 which used United States citizens as subjects. Such studies were difficult to find because often when sex is used as an independent variable, it is treated and discussed casually, if at all. Because of this, probably not all the relevant studies were found, but it is assumed that all important studies reported since 1960 have been included. The studies included have been grouped into broad age/grade categories.

Studies Related to Pre-School Subjects

Three investigators have reported on mathematical knowledge of boys and girls before they enter school, and these studies are summarized in Table I. None of the three studies report any significant differences between the mathematical knowledge of three, four, or five-year-old boys and girls. It seems safe to assume on the basis of the consistency of results of these three studies that boys and girls enter school with similar mathematical knowledge.

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Insert Table I about here

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Studies Related to Early Elementary School Children

Table II summarizes nine studies which used early elementary school children as subjects. One study (Hervey, 1966) indicated that boys performed better than did girls. One study (Lesser, Fifer, and Clark, 1965) showed that boys performed better on one scale. Two studies (Lowery and Allen, 1970; Wozencraft, 1963) indicated that girls performed better than boys. In the five other studies, involving a variety of measures of math-

ematical learning, no significant differences were found. From the results of these studies, it appears reasonable to conclude that there are no consistent significant differences in the learning of mathematics by boys and girls in the early elementary years.

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Insert Table II about here

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Studies Related to Older Children

The picture concerning differences in learning mathematics by boys and girls becomes more confused during the pre- and early adolescent years.

Eighteen studies summarized in Table III were found that used as subjects learners in this age range. These studies used a wide variety of instruments to assess learning. Nine studies used standardized achievement tests which commonly were divided into two subtests: reasoning and computation (or fundamentals). Even though different standardized tests were used, they undoubtedly measure similar kinds of learning so it is profitable to look at the results of these studies combined. Four studies (Cleveland and Bosworth, 1967; Parsley et. al., 1963; McGuire, 1961; and Gainer, 1962) report no significant differences. Zahn (1966) reported a difference which may be significant in favor of boys on the total score while Singhal and Crago (1971) and Wozencraft (1963) reported a significant difference in favor of girls on total score. Jarvis (1964) reported that boys scored significantly higher than girls on reasoning, while the reverse was true for computation. The superiority of girls over boys in computation was confirmed by Parsley, et. al. (1964).

Unkel (1966) investigated the discrepancy between an anticipated arith-

metic achievement (as determined by chronological age, grade placement, and mental age and actual arithmetic achievement of 918) children in grades 1-9. The California Achievement Test was the criterion measure. Interestingly, the girls had significantly higher discrepancy scores than the boys on tests involving arithmetic fundamentals. No significant difference in discrepancy scores was found in arithmetic reasoning. In other words, no significant differences were found between girls' and boys' performance on tests of arithmetic reasoning when intelligence was controlled but boys were performing significantly better on tests of arithmetic fundamentals. This finding appears to contradict the findings of Parsley and Jarvis who found girls significantly superior in arithmetic fundamentals. The discrepancy scores for boys and girls in arithmetic total score was surprisingly similar until 6th grade when the girls evidenced much higher discrepancy scores. This difference was in arithmetic fundamentals.

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Insert Table III about here

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One Parsley study (1964) has been widely quoted as supportive of the belief that boys achieve significantly better than girls in mathematics. Because this study used sex as the major independent variable and has affected the belief of many concerning achievement, it and the previous study on which it is based will be discussed in depth.

In 1963, Parsley et. al. reported a study which used 2,651 boys and 2,369 girls in grades 2-8 as subjects. Scores from the California Arithmetic test (Reasoning and Fundamentals) were analyzed on the basis of sex and critical ratios were reported. None of these ratios approached significance. The subjects were also categorized into five ability levels

by scores received on the California Test of Mental Ability and once again no significant differences between the sexes were found. These negligible results prompted the authors to duplicate the study the following year with 3,551 subjects and to add an additional analysis -- that of achievement level as it is related to intellectual ability (Parsley et. al., 1964). On the basis of this, children were categorized as under-, average-, or over-achievers. From this study the authors concluded that "Boys do excel in Arithmetic Reasoning, but not in Arithmetic Fundamentals." However, an examination of the data does not substantiate this conclusion. The number of significant differences found is shown in Table IV. In Arithmetic Reasoning, boys scored significantly higher than girls 12 times while girls scored significantly higher than boys 7 times. There were 75 individual comparisons (t tests) reported (five grades by five ability levels by three achievement levels). As there was no control for alpha level the strong conclusion reached by the authors does not appear warranted. In the area of Arithmetic Fundamentals girls scored significantly higher than boys 24 times while boys scored significantly higher than girls three times. The authors do not conclude that girls excel in Arithmetic Fundamentals even when the case for this conclusion is stronger than the case for the boys excelling in Arithmetic Reasoning.

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Insert Table IV about here

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The data were also examined to determine if ability level and achievement level were related to sex. Table V shows the significant differences found. Girls appear to out-perform boys in Arithmetic Fundamentals at all ability levels except the very highest while very bright boys outperform very bright

girls in Arithmetic Reasoning.

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Insert Table V about here

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It is not reasonable from this study to conclude that boys learn mathematics better than do girls. In fact, a strong case can be made for concluding that since girls outperform boys consistently in Arithmetic Fundamentals, girls learn mathematics better than do boys.

The National Longitudinal Study of Mathematical Ability (NLSMA) is one of the most extensive studies of mathematics achievement which has been done. Data concerning one group (the X-Population) were collected for five years as the students progressed from Grade 4 through Grade 8 (Carry and Weaver, 1969; Carry, 1970) and data from another group (the Y-Population) were collected for four years as the subjects progressed from Grade 7 through Grade 10 (McLeod & Kilpatrick, 1969 and 1971; Kilpatrick & McLeod, 1971).* Although the main variable studied was the impact of various textbook series on learning, sex was also used as a basis for analysis. The sex data analyses were reported in the appendices of the various volumes and while it appears that the differences found between the sexes were large enough to be educationally significant, practically no discussion of these results are included in the reports. Due to the lack of discussion concerning the sex differences which were found in this important series of studies, the data from these studies will be examined here.

Evaluation instruments used to assess learning at all grade levels were classified by categories of mathematical content (number systems, geometry, and algebra) and by cognitive complexity of the task (Computation, Compre-

* Data for the Z-Population were also collected but are unavailable at the present time.

hension, Application, and Analysis). Data collected from these instruments were first analyzed for a sex X textbook interaction and if no significant interaction was found, the data were analyzed for sex differences. Tables VI and VII provide summaries of the total number of tests at each grade level, at each cognitive complexity and the number of significant differences found between the performance of girls and boys.

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Insert Tables VI and VII about here

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In both populations girls performed slightly better than did boys in the least complex skill (Computation). In 21 out of 50 tests of Computation girls surpassed boys, while boys surpassed girls 11 times. However, the highest percent of significant differences were found in the X-Population at Grades 4-6. With the older subjects of the Y-Population fewer significant differences in computation were found. In the 77 tests of more complex cognitive skills (Comprehension, Application, and Analysis) five tests had results which favored the girls while 54 tests showed significant differences in favor of boys. The conclusion is inescapable that the boys of these populations learned the mathematics measured by these tests better than did the girls of these populations. While the girls appear to have done slightly better at younger ages in a low level cognitive skill, by the time puberty was well established (9th, 10th grades) boys are outperforming girls at all levels of cognitive complexity.

Six other studies are included in Table III. Muscio (1962) found significant differences in favor of boys on a test of quantitative understanding while Olander and Ehmer (1971) found significant differences in favor of girls in mathematical vocabulary. In tests which appear from their descriptions to measure abilities similar to those of Standardized tests (Reasoning), Alexander (1962) D'Augustine (1966) and Sowder (1971) found no

significant differences.

Sheehan (1968) found ambivalent results. In this study, ninth grade girls performed significantly better than did boys when learning to solve algebra problems. However, when the influence of eighth grade mathematics achievement, algebra aptitude, pre-instructional score, I.Q., and reading ability were eliminated, the boys' scores were significantly higher than the girls' scores. Why this last analysis was done is not clear as the subjects were randomly selected originally. Evidently girls had learned more before the study (as evidenced by eighth grade mathematics achievement- and pre-instructional score) and as a result were able to learn how to solve algebra problems better.

Although generalizing results from so many divergent studies which analyzed different aspects of mathematics learning hides subtle and important variations, it appears safe to conclude that in overall performance on tests measuring mathematics learning that there are no significant differences that consistently appear between the learning of boys and girls in the fourth to ninth grade. There appears to be a trend, however, that if a difference does exist, girls tend to perform better in tests of mathematics computation (Parsley, 1964; Wozencraft, 1963) and boys tend to perform better in tests of mathematical reasoning (Carry and Weaver, 1969; Carry, 1970; McLeod and Kilpatrick, 1969 and 1971; Kilpatrick and McLeod, 1971; Jarvis, 1964; Zahn, 1966; Muscio, 1962).

Studies Concerned with High School Subjects

Although there appear to be psychological studies which focus on analytical and spatial ability, studies dealing with sex differences explicitly in mathematics achievement at the secondary school level reported since 1960

are difficult to find.

When data concerning high school learners is considered, there are at least two important confounding factors. More boys than girls drop out of school and boys drop out at younger ages (Fitzsimmons, 1969). Lower ability boys tend to drop out so that most samples of high school boys are more homogeneous as far as ability is concerned than are the samples of girls. Girls do not elect mathematics courses as often as do boys. If, perchance, brighter girls tend not to elect mathematics, then a lower ability sample of girls will result. Comparing a sample of this type with a sample of boys from which lower ability learners have dropped out does not appear to be reasonable. Both of these confounding effects should be investigated before definite conclusions concerning this age group can be made. In Table VIII the three studies that were found are summarized. In one study (Backman, 1972) significant differences in favor of the boys were found. In one study (Easterday and Easterday, 1968) significant differences in favor of girls were found and in one study (Bhushan et. al., 1968) no significant differences were found. On the basis of these three different results, it is difficult to conclude anything but that more information is needed.

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Insert Table VIII about here

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Summary and Questions

The purpose of this paper was to critically examine relevant literature in order to answer the question: "Are there sex differences in mathematics achievement?" Thirty-three studies were reported which should help in answering the question, but an answer to part of the question appears clearer than other parts. No significant differences between boys' and girls' math-

ematics achievement were found before boys and girls entered elementary school or during early elementary years. In upper elementary and early high school years significant differences were not always apparent. However, when significant differences did appear they were more apt to be in the boys' favor when higher level cognitive tasks were being measured and in the girls' favor when lower level cognitive tasks were being measured. No conclusion can be reached concerning high school learners.

This review has raised more questions than it has answered.

1. Are there clearly identifiable, consistent differences in mathematics achievement which can be attributed to the sex of learners?
2. What is the relationship between sex role identity development and achievement in mathematics? As sexual role assumes increasing importance at puberty, the differences between the sexes in mathematics achievement appear to increase.
3. What sex-related factors influence mathematics achievement? Are these factors inherent or environmental? The lack of sexual differences in learning mathematics until fourth grade would suggest that these factors are environmental. On the other hand, Stafford (1972) suggests that inherent factors are more important.
4. Can learning environments be structured to enable boys and girls to achieve at similar levels in mathematics after puberty begins?
5. Is there "sexism" in mathematics education research and its reporting? The NLSMA Reports' emphasis and the conclusion reached in the Parsley study suggests that this question be considered.
6. Is there "sexism" in mathematics education? If mathematics educators believe that there is a sex difference in learning mathematics

(as was evidenced in the reviews cited) and have not attempted to help girls achieve at a similar level to boys, then this question must be answered in the affirmative.

Table I

Sex Differences in Mathematics Achievement

Pre-School

AUTHOR	AGE OF SUBJECT	DEPENDENT VARIABLE(S)	RESULTS
Estes & Combs (1966)	3 and 4 years	Perception of quantity (numerousness)	No significant differences between boys and girls found.
Brace & Nelson (1965)	Pre-school	Concept of number (rational counting, equivalent and non-equivalent sets, conservation of numerousness, cardinal and ordinal properties, place value)	No significant differences between boys and girls found.
Heard (1970)	Entering Kindergarten	Mathematical concepts and abilities possessed by Kindergarten entrants (SMSG Fall Inventory Test)	No significant differences between boys and girls found.

Table II

Sex Differences in Mathematics Achievement
Early Elementary School

Author	Grade	Dependent Variable(s)	Results
Van Engen & Steffe (1966)	1	Concept of addition	No significant differences found
Lowery & Allen (1970)	1	Ability to categorize items differing on one, two, or three attributes.	Girls performed significantly better than boys in middle and upper SES classes.
Engle & Lerch (1971)	1	Open and closed sentences	No significant differences found.
Almy (1970)	Longitudinal study; K, 1 and 2	Conservation of number and weight, class inclusion, seriation, ordination, reordering and transitivity.	"On an overall basis, the performance of the boys and girls is strikingly similar."
Hervey (1966)	2	Ability to solve verbal problems before instruction in the specific mathematical operation that would enhance the solution.	Boys solved significantly more problems than did girls before instruction.
Grouws (1971)	3	Ability to solve 4 types of open sentences involving addition.	No significant differences found.
Stern & Keislar (1967)	3	Ability to acquire a problem solving strategy (concept identification)	No significant differences found.

Table II con't

Author	Grade	Dependent Variable(s)	Results
Lesser, Fifer & Clark (1965)	1	Numerical Scale, space scale	No significant differences in numerical scale. Significant difference in favor of boys on space scale.
Wozencraft (1963)	3	Stanford Achievement Test	In Arithmetic Reasoning: Girls were significantly better in Total Group. Girls were significantly better in Middle IQ range. No significant differences in arithmetic computation.

Table III
Sex Differences in Mathematics Learning
Upper Elementary and Early High School Years

Author	Grade	Dependent Variable(s)	Results
McGuire (1961)	Junior High	Standardized Achievement Test	No significant differences found.
Gainer (1962)	6-12 years	Standardized Achievement Test	No significant differences found.
Wozencraft (1963)	6	Standardized Achievement Test	No significant differences found in Arithmetic Reasoning. Girls performed significantly better on Arithmetic Computation. On Arithmetic Average girls in Middle IQ range performed significantly better.
Parsley, et. al. (1963)	2-8	Standardized Achievement Test	No significant differences found.
Parsley, et. al. (1964)	4-8	Standardized Achievement Test	Boys with IQ of 125+ outperformed girls with similar IQs on arithmetic reasoning. Girls with IQs of 75-124 outperformed boys with similar IQs on arithmetic fundamentals. The overall differences appear to be non-significant.
Jarvis (1964)	6	Standardized Achievement Test	Boys tended to excel at reasoning at all IQ levels. Girls performed better in fundamentals in 3/4 IQ levels.
Cleveland & Bosworth (1967)	6	Standardized Achievement Test	No significant differences found. "Virtually no differences between the sexes in any aspect of arithmetic achievement."

Table III (con't)

Author	Grade	Dependent Variable(s)	Results
Zahn (1966)	8	Standardized Achievement Test	On 5 out of 32 subtests boys performed significantly better than girls. On 0 out of 32 subtests girls performed significantly better than boys.
Singhal & Crago (1971)	5-16 years K-11 grades	Wide Range Achievement Test (Level I)	Before instruction girls had higher grade-equivalent scores in arithmetic as a total group and at most grade levels. After six weeks (approx.) of instruction boys made gains significantly higher than girls in grades 3, 4 and 9. The differences in the total gains for boys and girls were non-significant.
Unkel (1966)	1-9	Discrepancies between actual achievement as measured by standardized achievement test and anticipated achievement as determined by CA, MA and grade placement. 3 SES groups used as independent variables.	Arithmetic reasoning: no significant differences in discrepancy scores between boys and girls. Arithmetic fundamentals: girls had higher discrepancy scores. Arithmetic totals: no significant differences between boys and girls on Total. Yet at grades 6,7,8 girls have significantly higher discrepancy scores with convergence again at grade 9.
Carry and Weaver (1969); Carry (1970)	Longitudinal 4-8	Computation, Comprehension, Application, Analysis in Algebra, Geometry and Number Systems	(See Table VI) In 38 out of 75 tests boys performed significantly better than girls. In 16 out of 75 tests girls performed significantly better than boys.

Table III (con't)

Author	Grade	Dependent Variable(s)	Results
McLeod and Kilpatrick (1969, 1971), Kilpatrick and McLeod (1971)	Longitudinal 7-10	Computation, Comprehension, Application, Analysis in Algebra, Geometry and Number Systems	(See Table VII) In 25 out of 51 tests boys performed significantly better than girls. In 10 out of 51 tests girls performed significantly better than boys.
Alexander (1962)	7	Arithmetic Reasoning Test	No significant differences found in ability to solve verbal problems.
Muscio (1962)	6	Quantitative Understanding	Boys performed significantly better than girls.
D'Augustine (1966)	5,6,7	Geometry and Topology	No significant differences found.
Olander & Ehmer (1971)	4,5,6	Mathematical vocabulary of children's contemporary mathematics texts.	Girls were significantly better at all 3 grades.
Sowder (1971)	4-7	Discovery of Patterns	No significant differences.
Sheehan (1968)	9	Ability to learn to solve algebra problems	Ambivalent results (see p. 8)

Table IV
Significant Differences Found Between
Males and Females in Arithmetic Reasoning and Fundamentals*

	Arithmetic Reasoning **		Arithmetic Fundamentals **	
Grade	Female	Male	Female	Male
4	1	4	0	0
5	1	3	1	3
6	2	2	7	0
7	1	2	9	0
8	2	1	7	0
Total	7	12	24	3

*Data from Parsley, Powell, and O'Connor (1964)
**75 possible comparisons

Table V
Significant Differences Found Between Five Ability Levels of
Males and Females in Arithmetic Reasoning and Fundamentals*

	Arithmetic Reasoning **		Arithmetic Fundamentals **	
IQ	Female	Male	Female	Male
75-94	4	1	4	2
95-104	1	3	7	0
105-114	1	0	6	0
115-124	0	2	5	0
125+	1	6	2	1

*Data from Parsley, Powell and O'Connor (1964)
** 15 Comparisons reported

Table VI

Sex Differences in Achievement
National Longitudinal Study of Mathematics Achievement
X-Population*

	Computation			Comprehension			Application			Analysis			All Tests		
Grade	Total[a]	Boys[b]	Girls[b]	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls
4 (Spring)	1	0	1	4	3	0	0	0	0	0	0	0	5	3	1
5 (Spring)	3	0	1	3	3	0	1	1	0	1	1	0	8	5	1
6 (Spring)	5	1	4	4	3	1	1	1	0	0	0	0	10	5	5
7 (Fall)	0	0	0	8	6	0	0	0	0	3	3	0	11	9	0
7 (Spring)	13	3	4	6	3	0	0	0	0	1	1	0	20	7	4
8 (Fall)	2	0	2	2	1	1	0	0	0	0	0	0	4	1	3
8 (Spring)	7	2	2	7	3	0	1	1	0	2	2	0	17	8	2
Total	31	6	14	34	22	2	3	3	0	7	7	0	75	38	16

[a]Total number of tests at each level.
[b]Indicates number of tests at each level in which significant differences ($p < .05$) were found.

*Data from:
Carry, L.R. and J.F. Weaver. Patterns of Mathematics Achievement in Grades 4, 5 and 6: X-Population. NLSMA Reports (#10). J.W. Wilson, L.S. Cahen, E.G. Begle, eds. (1969)

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Table VII

Sex Difference in Achievement
National Longitudinal Study of Mathematics Achievement
Y-Population*

	Computation			Comprehension			Application			Analysis			All Tests		
Grade	Total[a]	Boys[b]	Girls[b]	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls
7	7	3	3	3	2	0	1	1	0	0	0	0	11	6	3
8	6	2	3	4	1	1	0	0	0	6	5	0	16	8	4
9	3	0	1	6	2	0	0	0	0	2	2	0	11	4	1
10	2[c]	0	0	1	1	0	4	2	0	6	4	2	13	7	2
Total	18	5	7	14	6	1	5	3	0	14	11	2	51	25	10

[a]Total number of tests at each level.

[b]Indicates number of tests at each level in which significant difference in performance were found.

[c]One test was eliminated in this category due to significant sex x textbook interaction.

* Data from:

McLeod, G.K. and J. Kilpatrick, Patterns of Mathematics Achievement in Grades 7 and 8: Y-Population. NLSMA Report No. 12, J.W. Wilson, L.S. Cahen, and E.G. Begle, eds, Leland Stanford Junior University, 1969.

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Table VIII

Sex Differences in Mathematics Achievement

High School

Author	Grade	Content	Results
Bhushan et. al. (1968)	9, 10	Plane Geometry. Teacher made test	No significant differences
Easterday and Easterday (1968)	longitudinal 9, 10	Algebra	No significant differences in 9th grade pre- and post-tests. Significant differences in favor of the girls in 10th grade.
Backman, M.F. (1972)	12	Standardized achievement	Significant differences in favor of males.

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